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Methodology for Developing the Mathematical Competencies of Primary School Students with Hearing Impairments in Inclusive Education Through Visual-Didactic Technologies

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Abstract

This article examines the pedagogical and methodological foundations for developing the mathematical competencies of primary school students with hearing impairments in an inclusive education environment. It analyzes the educational potential of visual-didactic technologies in the process of mastering mathematical knowledge, the criteria for selecting visual materials in accordance with students' individual needs, and the methodological techniques that support the formation of mathematical concepts. A methodological approach based on the use of geometric models, digital images, color-coded diagrams, interactive tasks, and object-based practical activities is also proposed.

Keywords: Inclusive education, students with hearing impairments, primary education, mathematical competence, visual-didactic technologies, visualization, individualized approach, interactive learning, differentiated instruction.

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1. Introduction

Today, one of the key pedagogical tasks in the education system is to create conditions in which every child can receive a quality education that takes into account his or her individual abilities, needs, and developmental characteristics. In the development of inclusive education in particular, it is especially important that children with special educational needs adapt to the general education environment, acquire knowledge on the basis of equal opportunities, and develop independent thinking skills.

Primary education is an important stage at which the foundations are laid for a child's intellectual development, logical thinking, and cognitive activity. It is during this period that concepts such as number, quantity, shape, magnitude, spatial relations, arithmetic operations, and problem solving are formed. For children with hearing impairments, the process of mastering mathematical knowledge may depend directly on how

the learning material is presented, how pedagogical communication is organized, and how appropriately visual aids are selected.

When working with such students, relying only on oral explanation may not yield sufficient results. Limited hearing creates an additional need for visual supports in receiving and processing information. Therefore, during lessons it is necessary to use, in combination, visually perceived information, object-based actions, graphic images, and written instructions.

Visual-didactic technologies make it possible to present learning material in a visual form, to connect abstract mathematical concepts with concrete images, and to encourage students' independent activity. Their effective use contributes not only to the mastery of mathematical knowledge but also to the development of mental operations such as analysis, comparison, generalization, and drawing conclusions.

2. Aims and Objectives of the Study

The main aim of the study is to develop a methodological system aimed at developing the mathematical competencies of primary school students with hearing impairments in inclusive education on the basis of visual-didactic technologies, and to substantiate its pedagogical potential.

To achieve this aim, the following objectives were set:

- to analyze, from a pedagogical perspective, the characteristics of how primary school students with hearing impairments acquire mathematical knowledge;
- to clarify the structural components of mathematical competence;
- to reveal the didactic potential of visual-didactic aids in the learning process;
- to propose a system of lessons based on visual, object-based practical, and digital technologies;
- to develop methodological recommendations that take students' individual educational needs into account.

Pedagogical Features of Developing Mathematical Competencies in Students with Hearing Impairments

Mathematical competence refers to a student's ability to acquire mathematical knowledge, apply it in practical situations, analyze problem situations, and find solutions independently. In primary grades, this competence is formed through several closely interrelated components.

The first component is competence in understanding mathematical concepts. Here the student must understand the meaning of numbers, digits, quantitative relationships, geometric shapes, and mathematical symbols.

The second component is practical computational competence. It covers the skills of performing operations such as addition, subtraction, multiplication, and division, using calculation methods, and checking results.

The third component is logical thinking competence. In this component, the student develops the ability to group and compare objects, identify sequences, find patterns, and draw simple conclusions.

The fourth component is competence in applying mathematical knowledge in real-life situations. Examples include determining the number of items, comparing lengths, understanding time, working with monetary units, and solving problems related to everyday situations.

In developing these competencies in students with hearing impairments, it is important that the pedagogical process be clear, that instructions be consistent, and that information be expressed in a visually precise way. At the same time, each child's level of hearing, speech development, reading and writing skills, and individual perceptual characteristics must be taken into account. The educational needs of children with hearing impairments are not all the same.

Thus, an effective methodology is not limited to the general principle of visualization; it requires organizing learning situations adapted to each student's individual developmental capacities.

Educational Potential of Visual-Didactic Technologies

Visual-didactic technologies are a set of tools and methods that serve to perceive mathematical information visually, to organize it on the basis of specific signs, and to link it with practical activity.

The main pedagogical potential of these technologies lies in expressing the abstract content of mathematical concepts through clearly visible images. For example, when teaching the concept of number, using a corresponding number of objects rather than the numeral alone helps the student understand the relationship between number and quantity.

Visual-didactic aids can be divided into the following groups:

1. Object-based visual aids. Counting sticks, geometric shapes, colored cubes, number cards, objects of different sizes, and mathematical models belong to this group.

They help students master mathematical knowledge directly through action.

2. Graphic and schematic aids. Number lines, tables, diagrams, algorithmic schemes, comparison symbols, and pictorial models of a problem's conditions present mathematical information in an orderly form.

3. Digital visual aids. Interactive whiteboards, animated images, electronic presentations, mathematical games, and electronic tasks make it possible to organize the learning process in an engaging and active way.

4. Communicative-visual aids. Pictograms, short written instructions, mathematical symbols, materials adapted to sign language, and pictorial dictionaries facilitate communication between the teacher and the student.

When using these aids, what matters is not their number but their fit with the learning objective. Using excessive images, decorations, and colors at the same time may distract the child's attention from the main task. Therefore, visual materials should be simple, clear in content, and consistent.

3. Methodology for Developing Mathematical Competencies

It is advisable to organize the methodology for developing the mathematical competencies of primary school students with hearing impairments in several interrelated pedagogical stages.

Stage 1. Diagnostic and preparatory stage.

At this stage, the student's mathematical readiness, ideas about numbers, ability to distinguish geometric shapes, computational skills, and level of understanding of task content are determined. In diagnostics, one should not rely solely on oral questions and answers but should also use pictures, objects, cards, and practical tasks.

On the basis of the data obtained, the student's individual educational needs are identified and a set of adapted tasks is developed.

Stage 2. Visualization of mathematical concepts.

At this stage, new mathematical concepts are explained with the help of visual aids. For example, when teaching addition, two separate groups of objects are combined and the resulting total quantity is expressed with a numeral.

When explaining subtraction, the initial number of objects is shown, a certain part is removed, and the remaining quantity is determined. In this way, the student understands a mathematical operation not merely as a symbol but as an action with a specific meaning.

Stage 3. Organizing visual-practical activity.

At this stage, students independently count, group, and compare objects, combine shapes, and create mathematical models.

For example, when studying geometric shapes, students are given cards showing triangles, quadrilaterals, and circles. They sort the shapes by their features, identify similarities and differences, and compose new arrangements from the given shapes.

Stage 4. Consolidation and transfer.

Students are guided to apply the knowledge they have acquired in tasks of various kinds and in real-life situations. For example, through a shop game they perform exercises such as comparing prices, counting items, or choosing products that match a given amount of money.

At this stage, it is important to show how mathematical knowledge is connected with everyday life.

Examples of Organizing Lessons Based on Visual-Didactic Technologies

The following tasks can be used when putting the methodology into practice.

Task 1. "Number and Quantity"

Objective: to develop the connection between number and quantity.

The student is given cards showing the numbers from 1 to 10 and various quantities of objects. The student matches each numeral with the corresponding group of objects. In the next task, the student independently chooses the numeral that matches the number of objects.

Expected outcome: to understand the quantitative meaning of numbers and to develop counting skills.

Task 2. "The Colorful Math Bridge"

Objective: to convey the meaning of addition and subtraction.

The student is given cubes of different colors. First, three red cubes and two yellow cubes are combined. The student counts all the cubes and forms the expression 3 + 2 = 5. Then two cubes are removed, and a subtraction operation is carried out on the basis of the remaining quantity.

Expected outcome: to link arithmetic operations with object-based activity and to develop computational skills.

Task 3. "The World of Geometric Shapes"

Objective: to recognize, distinguish, and classify geometric shapes.

Students sort geometric shapes of different colors and sizes into groups. They then use these shapes to build a house, a tree, a vehicle, or other images. During the

activity, cards with the names of the shapes and the corresponding symbols are used.

Expected outcome: to develop geometric ideas, spatial perception, and classification skills.

Task 4. "Picture Problems"

Objective: to understand the conditions of a problem and arrive at a mathematical solution.

For example, the screen shows a picture of three apples and, next to it, a picture of two more apples. The student combines the pictures, determines the total number of apples, and writes the corresponding mathematical expression.

In subsequent lessons, short written conditions, diagrams, and tables are used instead of pictures.

Expected outcome: to develop the skills of understanding a mathematical situation through an image, analyzing the conditions of a problem, and expressing a solution.

Pedagogical Conditions Ensuring the Effectiveness of the Methodology

The effectiveness of using visual-didactic technologies depends on several important pedagogical conditions.

First, learning materials must be adapted to the student's individual hearing, speech, and cognitive abilities. In doing so, it is necessary to rely not only on the child's diagnosis but also on his or her actual educational needs and level of mastery.

Second, during the lesson the teacher's facial expressions and lip movements should be visible, and written instructions should be clear and understandable. Where necessary, the sign language and other communication aids used by the student are also incorporated into the learning process.

Third, visual materials should be chosen to match the content of the topic, and the transition from one task to another should be organized consistently.

Fourth, mathematical tasks should be arranged from easy to difficult and should allow the student to complete them independently.

Fifth, assessment should focus not only on the final result but also on the way the task is completed, the level of independence, and the ability to transfer knowledge to a new situation.

In addition, cooperation among the classroom teacher, the special education teacher, the teacher of the deaf, and parents is an important factor in supporting the student's educational development.

Criteria for Assessing the Development of Mathematical Competencies

The following criteria can be used to determine the effectiveness of the proposed methodology:

- Comprehension criterion: the ability to understand the content of mathematical concepts, numbers, and symbols.
- Practical criterion: performing arithmetic operations and independently using visual aids.
- Logical criterion: comparing objects, grouping them, identifying sequences, and drawing simple conclusions.
- Communicative criterion: expressing mathematical ideas in written, graphic, oral, or other communication forms suited to the student.
- Independence criterion: applying acquired mathematical knowledge in new tasks and everyday situations.

The assessment results can be conditionally described at three levels:

- Elementary level: when completing mathematical tasks, the student needs mostly the teacher's help and visual supports.
- Intermediate level: the student completes familiar types of tasks on the basis of visual instructions and can find independent solutions in some mathematical situations.
- High level: the student understands mathematical concepts, performs operations independently, and applies acquired knowledge in new practical situations.

These levels are proposed as methodological criteria for assessment; before they are put into practice, they should be adapted to students' age characteristics, the class curriculum, and individual learning goals.

4. Conclusion

In conclusion, developing the mathematical competencies of primary school students with hearing impairments in inclusive education is a complex, multifactorial pedagogical process that must be organized consistently. In this process, adapting the content of instruction to the student's individual abilities, presenting mathematical concepts in a visual form, and reinforcing them through practical activity are of great importance.

Based on the analysis, the following conclusions can be drawn:

- visual-didactic technologies create favorable pedagogical conditions for mastering mathematical concepts through concrete images and practical actions;
- the harmonious use of object-based models, graphic diagrams, digital images, and written instructions helps present mathematical information in an understandable form;
- organizing the learning process through the stages of diagnostics, visualization, practical activity, and consolidation ensures methodological consistency;
- taking students' individual needs into account, creating communicative accessibility, and using differentiated tasks support the effectiveness of learning;
- in assessing mathematical competencies, indicators of knowledge, practical skills, logical thinking, and independent activity must be considered together.

Thus, visual-didactic technologies emerge as an important methodological tool for supporting the mastery of mathematical knowledge in inclusive primary education. Applying them purposefully, consistently, and on the basis of an individualized approach expands the pedagogical opportunities needed for developing the mathematical competencies of students with hearing impairments.

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